

CLAIMS

What is claimed is:

1. A steering control device for use in a vehicle having a steering wheel that receives steering input, and an electronically-controlled steering unit that turns the vehicle's wheels over a road surface based on the position of the steering wheel, comprising:
 - a reaction force device coupled to the steering wheel and responsive to a control signal to apply a steering reaction force to the steering wheel; and
 - a controller adapted to generate the control signal in response to the movement of the steering wheel and the road surface reaction force, wherein the controller varies the control signal to increase the steering reaction force in response to the road surface reaction force, and the controller determines the reaction force is larger when the steering wheel is turning than when the steering wheel is returning.
2. The steering control device of Claim 1, wherein the controller is responsive to the angular velocity of the steering wheel, and is further adapted to vary the control signal as a function of steering wheel angular velocity.
3. The steering control device of Claim 2, wherein the controller varies the control signal to decrease the steering reaction force at higher steering angular velocities.
4. The vehicle steering control device of Claim 1, further comprising vehicle speed sensor wherein the controller is responsive to vehicle speed sensor and is further adapted to vary the control signal as a function of vehicle speed.
5. The steering control device of Claim 3, wherein the controller varies the control signal to decrease the reaction force at lower vehicle speed.
6. The steering control device of Claim 1, wherein the controller is further adapted to calculate a vehicle state and an estimated steering force correction value based on the vehicle state, wherein the controller varies the control signal as a function of the estimated steering force correction value.

7. The steering control device of Claim 6, wherein the controller varies the control signal to increase the steering reaction force by the steering force correction value.
8. The steering control device of Claim 6, wherein the vehicle state is calculated based on information of the vehicle speed and yaw.
9. The vehicle steering control device of Claim 1 wherein the controller is further adapted to calculate whether the vehicle is within a rotation limit based on the angle of the wheels and the yaw rate of the vehicle, and wherein the controller does not reduce the steering reaction force when the controller determines that the vehicle is within the rotation limit.
10. A vehicle, comprising:
- (a) a steering wheel that receives steering input from an operator;
 - (b) an electronically controlled-steering device that turns the vehicle's wheels over a road surface based on the position of the steering wheel;
 - (c) a reaction force device coupled to the steering wheel and responsive to a control signal to apply a steering reaction force to the steering wheel; and
 - (d) and a controller adapted to generate the control signal in response to the movement of the steering wheel and the road surface reaction force, wherein the controller varies the control signal to increase the steering reaction force in response to the road surface force when the steering wheel is turning and to decrease the steering reaction force in response to the road surface force when the steering wheel is returning.
11. The steering control device of Claim 10, wherein the controller is responsive to the angular velocity of the steering wheel, and is further adapted to vary the control signal as a function of steering wheel angular velocity.
12. The steering control device of Claim 11, wherein the controller varies the control signal to decrease the reaction force at higher steering angular velocities.
13. The vehicle steering control device of Claim 10, further comprising vehicle speed sensor wherein the controller is responsive to vehicle speed sensor and is further adapted to vary the control signal as a function of vehicle speed.

14. The steering control device of Claim 13, wherein the controller varies the control signal to decrease the reaction force at lower vehicle speed.
15. The steering control device of Claim 10, wherein the controller is further adapted to calculate a vehicle state and estimate a steering force correction value based on the vehicle state, wherein the controller varies the control signal as a function of the estimated steering force correction value.
16. The steering control device of Claim 15, wherein the controller varies the control signal to increase the reaction force by the steering force correction value.
17. The vehicle steering control device of Claim 10, wherein the controller is further adapted to calculate whether the vehicle is within a rotation limit based on the angle of the wheels and the yaw rate of the vehicle, and wherein the controller does not reduce the steering reaction force when the controller determines that the vehicle is within the rotation limit.
18. A steering control apparatus for use in a vehicle having a steering wheel and a reaction device to impose a steering reaction force onto the steering wheel in response to a steering force control signal, comprising:
- steering force correction means for calculating the steering force control signal based on a road surface reaction force and a gain;
 - judgment means for determining whether the steering wheel is in a turning or returning mode; and
 - control means for setting the gain at a higher value when the steering wheel is in a turning mode.
19. A method for controlling steering in a vehicle having a steering wheel and a reaction device to impose a steering reaction force onto the steering wheel in response to a steering force control signal, comprising:
- calculating the steering force control signal based on a road surface reaction force and a gain;
 - determining whether the steering wheel is in a turning or returning mode; and
 - setting the gain at a higher value when the steering wheel is in a turning mode.

20. The method of claim 19, further comprising:
determining the angular velocity of the steering wheel; and
setting the gain at a lower value when the steering wheel has a higher angular velocity.
21. The method of claim 19, further comprising:
determining the vehicle speed; and
setting the gain at a lower value when vehicle speed is lower.
22. The method of claim 19, further comprising:
calculating a vehicle state value; and
estimating a steering reaction force correction value from the vehicle state value; and
adding the steering reaction force correction value to the steering force control signal.
23. The method of claim 19, further comprising:
determining whether the vehicle is within a rotation limit; and
setting the gain to a predetermined high value when the vehicle is within the rotation limit.